

REMARKS

I. Status of the Claims

Claims 1-21, 23-26 and 29-78 are pending in the Application. Claim 27 was previously cancelled. Claims 22 and 28 have been cancelled without prejudice or disclaimer. Claims 39-73 were previously withdrawn.

Independent claims 1, 23 and 74 have been amended in order to more clearly define the invention and expedite prosecution. Specifically, the independent claims have been amended to indicate that metal catalyst precursors are selectively docked on at least one end of at least some of the sorted cut carbon nanotubes. Support for this amendment can be found at least in Paragraphs 15, 65-66 and Figure 7 of the Application. The independent claims have also been amended to indicate that the carbon nanotube product is of a single electronic type. Support for this amendment can be found at least in Paragraphs 5, 11, 82 and Figure 7 of the Application. In addition, various limitations from cancelled claim 28 were added to independent claim 23.

II. Examiner Interview

In response to the Office Action, Applicants held an interview by telephone on November 1, 2011 with Examiner Daniel McCracken (hereinafter "Interview"). Applicants' representatives, Dr. Farhang Amini and Mr. Robert Shaddox, participated in the Interview. Two of the inventors of this Application, Dr. James M. Tour and Dr. Robert H. Hauge, also participated in the Interview.

During the Interview, Applicants summarized the key aspects of the invention. Specifically, Applicants indicated that the claimed invention generally pertains to the bulk growth of carbon nanotubes (CNTs) of a single electronic type by the following general steps: (1) cutting a plurality of CNTs to provide cut CNTs; (2) sorting the cut CNTs by electronic type to provide sorted cut CNTs; (3) selectively docking at least one end of the sorted cut CNTs to metal catalyst precursors to form CNT seeds; and (4) growing the CNT seeds to form a CNT product of increased length and a single electronic type.

Applicants also pointed out that, prior to the invention, no methods existed for producing large quantities of CNTs that had a precisely defined electronic type. Applicants also pointed out

that the claimed invention provides an unmet need in producing bulk quantities of CNTs of a single electronic type for use in numerous electronic devices.

Applicants further emphasized that a key aspect of the claimed invention was the step of selectively docking at least one end of the sorted cut CNTs to metal catalyst precursors. Specifically, Applicants indicated that, without such selective docking, CNT amplification of a single electronic type could not have occurred.

Applicants also discussed the defects with respect to the claimed invention in the Margrave reference (U.S. Pat. App. Pub. No. 2002/0004028). As discussed in more detail below, Applicants indicated that Margrave remained silent on sorting any CNTs by electronic type and selectively docking at least one end of sorted CNTs to metal catalyst precursors to form CNT seeds. Due to the aforementioned defects, Applicants also indicated that a reasonable expectation of success for the claimed invention did not exist in Margrave.

As understood by Applicants, the Examiner provisionally agreed that Margrave did not teach or suggest any methods of selectively docking at least one end of the sorted cut CNTs to metal catalyst precursors to form CNT seeds. As further understood by Applicants, the Examiner indicated that the allowability of the claims would be considered if Applicants filed this Response.

Applicants thank the Examiner for devoting time to discuss this case. Applicants hereby address the Examiner's remarks in the order that they appeared in the Office Action.

III. Rejections under 35 U.S.C. § 112

In the Office Action, the Examiner rejected claims 22-23 and 28 under 35 U.S.C. § 112 (second paragraph) for allegedly being indefinite. Office Action, page 5. Applicants respectfully submit that amendments to claim 23 render the rejection of that claim as moot. The rejections of claims 22 and 28 are also considered moot in view of the cancellation of those claims.

IV. Rejections under 35 U.S.C. § 103(a)

In the Office Action, the Examiner rejected claims 1-3, 6-7, 10, 13, 17-25, 28-29, 31, 34, 36-38 and 76-78 under 35 U.S.C. § 103(a) as allegedly being obvious over U.S. Pat. App. Pub. No. 2002/0004028 to Margrave et al. (hereinafter "Margrave") in view of Applicant's admissions. Office Action, pages 6-9. In addition, the Examiner rejected claims 8-9 under 35

U.S.C. § 103(a) as allegedly being obvious over Margrave, in view of Applicant's admissions, and in further view of a Science article by Strano et al. entitled "Electronic Structure Control of Single-walled Carbon Nanotube Functionalization" (301:2003, pp. 1519-1522, hereinafter "Strano"). Office Action, pages 9-10. The Examiner also rejected claims 4 and 16 under 35 U.S.C. § 103(a) as allegedly being obvious over Margrave in view of U.S. Pat. No. 6,413,487 to Resasco et al. (hereinafter "Resasco"). Office Action, page 10. In addition, the Examiner rejected claims 5 and 30 under 35 U.S.C. § 103(a) as allegedly being obvious over Margrave in view of a Nano Letters reference by Gu et al. entitled "Cutting Single-Wall Carbon Nanotubes through Fluorination" (2002, 2(9):1009-1013, hereinafter "Gu"). Office Action, page 11. The Examiner also rejected claims 11-12, 14-15, 32-34 and 74-75 under 35 U.S.C. § 103(a) as allegedly being obvious over Margrave in view of a Journal of American Chemical Society article by An et al. entitled "Synthesis of Nearly Uniform Single-walled Carbon Nanotubes Using Identical Metal-Containing Molecular Nanoclusters as Catalysts" (2002, 124(46):13688-13689, hereinafter "An"). Office Action, pages 11-12. In addition, the Examiner rejected claim 26 under 35 U.S.C. § 103(a) as allegedly being obvious over Margrave in view of an Applied Physics article by Dillon et al. entitled "Hydrogen storage using carbon adsorbents: past, present and future" (2001, 72:133-142, hereinafter "Dillon"). Office Action, page 12. For the reasons set forth below, Applicants respectfully traverse these rejections.

For rejections to be proper under 35 U.S.C. § 103(a), all claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 985 (C.C.P.A. 1974). In addition, a reasonable expectation of success for the claimed invention must be founded in the prior art. *See* M.P.E.P. §2143.02 (citing *In re Rinehart*, 531 F.2d 1048 (CCPA 1976)). *Also see In re Dow Chem. Co.*, 837 F.2d 469, 473 (Fed. Cir. 1988) (stating that "[b]oth the suggestion and the expectation of success must be founded in the prior art, not in applicant's disclosure.")

Furthermore, the Examiner must provide an explanation as to why any differences between the prior art and the claimed invention would have been obvious to one of ordinary skill in the art. M.P.E.P. §2141; *KSR Intern. Co. v. Teleflex Inc.*, 127 S.Ct. 1727, 1741 (U.S., 2007) ("[R]ejections on obviousness cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness", quoting *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)).

In addition, the Examiner may not rely on hindsight bias without considering the claimed invention and the prior art as a whole in accordance with the requisite *Graham* factual inquiries. M.P.E.P. §2141; *Ruiz v. A.B. Chance Co.* 69 U.S.P.Q.2d 1686, 1690 (Fed. Cir. 2004) (stating that "Section 103 precludes...hindsight discounting of the value of new combinations by requiring assessment of the invention **as a whole**....by requiring a showing that an artisan of ordinary skill in the art **at the time of invention**, confronted by the **same problems** as the inventor and with **no knowledge of the claimed invention**, would select the various elements from the prior art and combine them in the claimed manner.") (emphasis added).

Furthermore, in considering the invention and the prior art as a whole, Examiners must also consider portions of references that would teach away from a claimed invention. M.P.E.P. §2141.02. More specifically, an Examiner must not disregard "disclosures in the references that diverge from and teach away from the invention at hand" *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 1550 (Fed. Cir. 1983) (cited in M.P.E.P. §2141.02).

However, when one compares the limitations of the rejected claim and the cited references as a whole, significant differences become apparent. Such differences indicate that a person of ordinary skill in the art at the time of the present invention would not have combined or modified the various elements from Margrave, Resasco, Gu, An and Dillon in the claimed manner with a reasonable expectation of success. In addition, Strano is not a prior art reference as a matter of law because it describes Applicants' own work.

A. Margrave

Margrave remains silent on sorting cut CNTs by electronic type, as required for the rejected claims. *See* Declaration of Dr. James M. Tour and Dr. Robert H. Hauge under 37 C.F.R. §1.132 (hereinafter "Declaration"), Paragraph 7. Furthermore, Margrave does not teach or suggest any methods of selectively docking at least one end of the sorted cut CNTs to metal catalyst precursors to form CNT seeds, as currently required for the rejected claims. *Id.* In contrast, Margrave's methods result in the general placement of metal catalyst precursors on multiple areas on the CNTs (including the CNT sidewalls), not selectively on the CNT ends. *Id.*

Specifically, Margrave discloses a process of covalently bonding chelating agents to the sidewalls of fluorinated carbon nanotubes by replacement reactions where chelating agents

replace fluorine groups. *See, e.g.*, Paragraph 169 and Declaration, Paragraph 7. In fact, such a divergent approach in Margrave teaches away from the claimed invention.

Furthermore, Margrave provides a non-enabling disclosure with respect to the claimed invention. For instance, even though Margrave indicates that metal ions (such as Fe^{+3}) could migrate to CNT ends (*See, e.g.*, Paragraph 169), such a migration as disclosed in Margrave cannot lead to the selective docking of metal catalysts to the ends of CNTs. *See* Declaration, Paragraph 8. In contrast, the addition of metal ions to CNTs via chelating groups (as disclosed in Paragraph 169 of Margrave) would lead to thermal defunctionalization and subsequent loss of the metal ions at higher temperatures (i.e., about 250 °C to 300 °C). *See, e.g.*, Abstract and Paragraphs 26 and 30-32 of U.S. Pat. App. No. 10/573,902, entitled “Thermal treatment of functionalized carbon nanotubes in solution to effect their functionalization.” *Also see* Declaration, Paragraph 8.

Moreover, even if the metal atoms disclosed in Margrave stayed on the CNT sidewalls, the metal atoms would not migrate to the ends of the CNTs. Declaration, Paragraph 9. Instead, the metal atoms would degrade the CNTs. *Id.* For instance, upon heat treatment, the iron atoms on the CNTs would catalytically react with the CNT sidewalls and expel small carbon species that would generate holes on the CNT sidewalls. *Id.* This would in turn lead to the destruction of the CNTs. *Id.*

Thus, in view of the aforementioned defects in Margrave, a reasonable expectation of success does not exist in Margrave for selectively docking at least one end of CNTs to metal catalyst precursors to form CNT seeds. *Id.* at Paragraph 10. As such, a reasonable expectation of success also does not exist in Margrave for growing CNT seeds to form a CNT product of a single electronic type, as also required for the rejected claims. *Id.* Rather, the absence of selective docking of metal catalysts to CNT ends in Margrave would prevent the amplification of any CNT products, including CNT products of a single electronic type. *Id.*

With respect to rejected claims 7-9, Margrave also does not teach or suggest any methods for sorting carbon nanotubes by electronic type through “selective chemical derivatization”, “selective extraction”, “selective precipitation”, “selective chemical functionalization”, “selective protonation”, or “superacid extraction”, as required for those claims.

B. Resasco

Resasco does not cure the aforementioned defects in Margrave. For instance, Resasco discloses methods and apparatus for catalytic production of carbon nanotubes. *See, e.g.*, Abstract and Declaration, Paragraph 11. Yet, the disclosed methods and apparatus in Resasco do not teach or suggest any methods for sorting CNTs by electronic type, as required for the rejected claims. *See* Declaration, Paragraph 11. In fact, Applicants are unaware of any disclosure in Resasco that even pertains to the sorting of the catalytically produced carbon nanotubes. *Id.* Accordingly, Resasco also does not teach or suggest any methods of growing CNT seeds to form CNT products of a single electronic type. *Id.*

C. Gu

The disclosure in Gu is also defective with respect to the claimed invention. *Id.* at Paragraph 12. For instance, rather than disclosing methods for sorting CNTs by electronic type, Gu focuses exclusively on methods of “*Cutting* Single-Wall Carbon Nanotubes through Fluorination.” *See, e.g.*, Title and Abstract (emphasis added). *Also see* Declaration, Paragraph 12. Thus, Gu also does not teach or suggest any methods of growing CNT seeds to form CNT products of a single electronic type. Declaration, Paragraph 12.

D. An

An also does not cure the aforementioned defects in Gu, Resasco and Margrave. *Id.* at Paragraph 13. In particular, An focuses on a specific method of synthesizing uniform single-walled carbon nanotubes by utilizing metal-containing molecular nanoclusters as catalysts. *See, e.g.*, Title and page 13689 (col. 2). *Also see* Declaration, Paragraph 13. However, An remains entirely silent on any methods of sorting the synthesized carbon nanotubes, including sorting CNTs by electronic type. *See* Declaration, Paragraph 13. Accordingly, An also does not teach or suggest any methods of growing CNT seeds to form CNT products of a single electronic type. *Id.*

E. Dillon

The disclosure in Dillon also does not cure the aforementioned defects in An, Gu, Resasco and Margrave. *Id.* at Paragraph 14. Rather, the disclosure in Dillon pertains to a summary of hydrogen storage methods that utilize carbon adsorbents. *See, e.g.*, Abstract of Dillon. *Also see* Declaration, Paragraph 14. Therefore, and not surprisingly, Dillon also remains entirely silent on

any methods of sorting CNTs by electronic type or growing CNT seeds to form CNT product of a single electronic type. *See* Declaration, Paragraph 14.

F. Strano

Strano cannot be considered as a prior art reference as a matter of law. *See* M.P.E.P. §2132.01 (indicating that applicants' own work that is available as a reference only under 35 U.S.C. § 102(a) cannot be considered as a prior art reference).

Strano was published on September 12, 2003, less than one year prior to the effective filing date of this Application (October 14, 2003, the filing date of Provisional Application No. 60/511,175). Thus, Strano is only available as a reference under 35 U.S.C. § 102(a).

Furthermore, four of the inventors of this Application are also co-authors of Strano. The four inventors are Dr. James M. Tour, Dr. Christopher A. Dyke, Dr. Robert H. Hauge, and Dr. Richard E. Smalley (now deceased). In accordance with M.P.E.P. §2132.01, Applicants hereby present 37 CFR §1.132 Declarations of Dr. James M. Tour, Dr. Christopher A. Dyke and Dr. Robert H. Hauge. The Declarations affirm that Strano describes Applicants' own work.

CONCLUSION

For at least the reasons stated above, Applicants assert that claims 1-21, 23-26, 29-38 and 74-78 are in condition for allowance. Accordingly, Applicants respectfully request an allowance of the aforementioned claims. Applicants also request that the Examiner call Applicants' Attorney at the below listed number if the Examiner believes that such a discussion would be helpful in resolving any remaining issues.

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Respectfully submitted,

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